Claims

1. A method for transferring substances between layers of fluid or gas, said method comprising
   i. providing a device comprising
      a. at least one convective layer comprising a fluid or gas of interest, wherein said at least one convective layer has a thickness between 1 mm and 5 cm, and
      b. at least one receiving layer, comprising fluid or gas to which receiving layer or from which receiving layer the substances are transferred,
   ii. passing a fluid or gas through said device, wherein said fluid or gas of interest within said at least one convective layer is running in a direction parallel to said at least one receiving layer, and wherein fluid or gas in said at least one receiving layer is either:
      a. stagnant, or
      b. running in another direction, and/or running with a different speed, when compared to the fluid or gas in said at least one convective layer,
   iii. allowing substances to be transferred to or from said at least one receiving layer without said receiving layer being percolated by said fluid or gas of interest of the convective layer, and
   iv. obtaining a fluid or gas of interest in said at least one convective layer from which or to which said substances are transferred.

2. The method according to claim 1, wherein the receiving layer is positioned below the convective layer.

3. The method according to any of the preceding claims, wherein the substances are transferred to the at least one receiving layer due to sedimentation, mixing layer mass flow, and/or diffusion.

4. The method according to any of the preceding claims, wherein the substances are retained within the receiving layer by precipitation, sorption or any other retention mechanism.

5. The method according to any of the preceding claims, where the receiving layer further has an affinity for the substances.

6. The method according to any of the preceding claims, where the receiving layer comprises at least one micro-organism capable of converting the substances.

7. The method according to claim 6, where the substances move from the receiving layer into a second convective layer adjacent the receiving layer and opposite the first convective layer.

8. The method according to any of the preceding claims, where the filter further comprises a second receiving layer adjacent the convective layer and opposite the first receiving layer.

9. The method according to any of the preceding claims, where at least one receiving layer comprises material selected from the list consisting of sand, gravel, perlite, vermiculite, anthracite, activated carbon, charcoal, limed soil, iron-enriched soil, diatomaceous soil, chitin, chitosan, pozzolan, lime, marble, clay, iron-oxide-coated minerals (e.g. sand), double metal-hydroxides, LECA, rockwool, glasswool, zeolithes, fly ash, soil, humus, bark, lignin, compost, leaves, seaweed, algae, alginate, xanthate, peat moss, bone gelatin beads, moss, wool, cotton, other plant fibres.

10. The method according to any of the preceding claims, wherein a receiving layer comprises trapped sediment as a sorbent.

11. The method according to any of the preceding claims, wherein the convective layer is empty space.

12. The method according to any of the preceding claims, wherein the convective layer comprises a non-absorbent, water-permeable, fibrous mesh material formed with circuitous pathways therethrough.

13. The method according to any of the preceding claims, wherein the at least one convective layer comprises a mass of random filament-type plastic fibers with a

density which is sufficient to support the filter unit without significant collapse, but allow water to pass freely therethrough.

14. The method according to claim 13, wherein the convective layer comprises a polyethylene or polyester fibrous mesh.

15. The method according to claim 14, wherein the convective layer comprises ENKADRAIN 8004H/5-2s/D110P manufactured by Colbond Geosynthetics, Arnhem, the Netherlands.

16. The method according to claim 14, wherein the convective layer comprises FIBERBOND EM 6645 manufactured by Fiberbond in Michigan City, Ind.

17. The method according to any of the preceding claims, wherein the convective layer comprises a mass of open-structured plant fibers with a density which is sufficient to support the filter unit without significant collapse, but allow water to pass freely therethrough.

18. The method according to claim 17, wherein the plant fibers comprise a mat of bark, chunk-wood, chip-wood, or straw.

19. The method according to any of the preceding claims, wherein the hydraulic conductivity of the convective layer is at least 1.1 times the hydraulic conductivity of the receiving layer in the main flow direction.

20. The method according to any of the preceding claims, wherein the difference in hydraulic conductivity between the receiving and convective layer along the axis of the main direction of flow in the connective layer is at least a factor 2, more preferably at least a factor 10, more preferably at least a factor 10^2, more preferably at least 10^3, more preferably at least 10^4, such as at least 10^5, for example at least 10^6.

21. The method according to any of the preceding claims, wherein the liquid to be filtered comprises waste water, industrial waste water (pharma, oil, chemical, metal, food and feed industry), urban waste water, highway runoff, stormwater.

22. The method according to any of the preceding claims, wherein the liquid to be filtered comprises urban waste water, highway runoff, road runoff and/or stormwater.

23. The method according to any of the preceding claims, wherein the pollutant is selected from the group consisting of: hydrocarbons, oil, heavy metals, hormones, PAH, pesticides, pharmaceuticals, MTBE, inorganic ions (nitrite, nitrate, phosphate, sodium), colloids below 20 µm, BAM, chlorinated fluids.

24. The method according to claim 1, further comprising passing the liquid or gas through a pre-filter to remove particulate material prior to the removal or enhancement steps.

25. The method according to claim 24, wherein particulate material with a mean size above 250 µm is removed.

26. A device for transferring substances between layers of fluid or gas, said device comprises at least one unit of a filter, said unit of a filter comprising

i. at least one convective layer comprising a fluid or gas of interest, wherein said at least one convective layer has a thickness between 1 mm and 5 cm,

ii. at least one receiving layer comprising fluid or gas to which receiving layer or from which receiving layer the substances are transferred,

wherein said fluid or gas of interest within said at least one convective layer is running in a direction parallel to said at least one receiving layer, and wherein fluid or gas in said at least one receiving layers is either:

- stagnant, or
- running in another direction, and/or running with a different speed, when compared to the fluid or gas in the convective layer,

and wherein said substances are transferred to or from said at least one receiving layer without said receiving layers being percolated by said fluid or gas of interest of the convective layer.

27. The device according to claim 26, further comprising a second receiving layer adjacent the convective layer opposite the at least one receiving layer, being a sandwich filter.

28. The device according to claim 27, comprising a stack of sandwich filters, the stack comprising at least 2 sandwich filters, such as at least 3 sandwich filters, for example at least 4 sandwich filters, such as at least 5 sandwich filters, for example at least 6 sandwich filters, such as at least 7 sandwich filters, for example at least 8 sandwich filters, such as at least 9 sandwich filters, for example at least 10 sandwich filters, such as at least 12 sandwich filters, for example at least 15 sandwich filters, such as at least 20 sandwich filters, for example at least 25 sandwich filters.

29. The device according to claim 26, comprising a stack of alternating convective/receiving layers.

30. The device according to claim 29, comprising a stack of at least 2 convective/receiving layers, such as at least 3 layers, for example at least 4 layers, such as at least 5 layers, for example at least 6 layers, such as at least 7 layers, for example at least 8 layers, such as at least 9 layers, for example at least 10 layers, such as at least 12 layers, for example at least 15 layers, such as at least 20 layers, for example at least 25 layers.

31. The device according to claim 26, wherein an impermeable layer surrounds the device to seal it from the surroundings on all surfaces except the inlet and outlet.

32. The device according to any of claim 26 to 31, wherein the receiving layers comprises material selected from the group consisting of sand, gravel, perlite, vermiculite, anthracite, activated carbon, charcoal, soil, limed soil, iron-enriched soil, diatomaceous soil, chitin, chitosan, pozzolan, lime, marble, clay, iron-oxide-coated minerals, e.g. sand, double metal-hydroxides, LECA, rockwool, zeolithes, fly ash, soil, bark, lignin, compost, seaweed, algae, alginate, xanthate, peat moss, bone gelatin beads, moss, wool, cotton, other plant fibres, and modification hereof.

33. The device according to any of claim 26 to 32, wherein the receiving layer comprises trapped sediment as a sorbent.

34. The device according to any of claim 26 to 33, wherein the convective layer consisting of a non-absorbent, water-permeable, fibrous mesh material formed with circuitous pathways there through.

35. The device according to any of claim 26 to 34, wherein the convective layer comprises a mass of random filament-type plastic fibers with a density which is sufficient to support the device without significant collapse, but allow water to pass freely there through.

36. The device according to any of claim 26 to 35, wherein the convective layer comprises a polyethylene or polyester fibrous mesh.

37. The device according to any of claim 26 to 33, wherein the convective layer comprises ENKADRAIN 8004H/5-2s/D110P manufactured by Colbond Geosynthetics, Arnhem, the Netherlands.

38. The device according to any of claim 26 to 33, wherein the convective layer comprises FIBERBOND EM 6645 manufactured by Fiberbond in Michigan City, Ind.

39. The device according to any of claim 26 to 33, wherein the convective layer comprises a mass of open-structured plant fibers with a density which is sufficient to support the device without significant collapse, but allow water to pass freely there through.

40. The device according to claim 39, wherein the plant fibers comprise a mat of bark, chunk-wood, chip-wood, or straw.

41. The device according to any of claim 26 to 40, wherein the hydraulic conductivity of the convective layer is at least two times the hydraulic conductivity of the receiving layer in the main flow direction, more preferably at least ten times.

42. The device according to any of claim 26 to 40, wherein the difference in hydraulic conductivity between the receiving and convective layer along the axis of the main direction of flow in the connective layer is at least a factor 10, more preferably at least a factor 10^2, more preferably at least 10^3, more preferably at least 10^4, such as at least 10^5, for example at least 10^6.

43. The device according to any of claim 26 to 42, being in the form of a roll.

44. The device according to claim 43, having at least two rounds, such as at least 3 rounds, for example at least 4 rounds, such as at least 5 rounds, for example at least 6 rounds, such as at least 7 rounds, for example 8 rounds, such as at least 9 rounds, for example at least 10 rounds, such as at least 12 rounds, for example at least 15 rounds, such as at least 20 rounds, for example at least 25 rounds of receiving/convective layer or receiving/convective/receiving layer.

45. The device according to any of claim 26 to 44, further comprising a pump for pumping liquid or gas through the filter unit.

46. The device according to any of claim 26 to 45, further comprising a pre-filter adapted to remove particulate material from the liquid or gas prior to passing the liquid or gas into the filter.

47. The device according to claim 46, wherein the pre-filter is adapted to remove particles above 250 µm.

48. Use of the device according to claims 26 to 47 for filtering wastewater.

49. The use of claim 48, wherein the wastewater is stormwater runoff, stormwater drain, highway runoff, urban runoff, urban stormwater.

50. Use of the device according to claims 26 to 46 for filtering gas (flue gas, waste gas, exhaust gas).

51. Use of the device according to claims 26 to 46 for filtering oil.